

How do drug lords in final destination countries respond to anti-drug policies?*

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Abstract

This paper models how drug lords in final destination countries respond to two types of government anti-drug policies: demand and supply oriented. Supply policies (crop eradication, interdiction, etcetera) are modeled in line with the previous literature, that is, they increase production costs. Demand policies (domestic law enforcement, demand reduction programs, etcetera) are modeled within a conflict framework with drug lords over the control of distribution channels for illegal drugs, which is novel. The model predicts drug use, price and indirectly drug related violent crime. These predictions appear to be consistent with the data.

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1 Introduction

According to the US Office of National Drug Control Policy (ONDCP), the total economic costs for society of drug use was estimated at \$ 168 billion in 2000, which corresponds to about 1.6% of total US GDP. The cost is composed of health care costs, productivity losses, costs of drug related crime, social welfare and the criminal justice system.¹ Two decades ago, the US government started a war on drugs with the dual objective of reducing the consumption of illegal drugs and associated violent crime by means of demand reduction policies, domestic law enforcement, international drug source policies and interdiction. The consumption of illegal drugs has, indeed, to a large extent, decreased over the last 20 years. However, despite efforts to make illegal drugs more expensive, the price has, in fact, dropped in this period of time. Furthermore, drug related violent crime actually increased for many years before falling back. These two puzzling facts are poorly understood by the previous literature. However, we provide a possible theoretical explanation for these phenomena.

This paper focuses on the final destination country for drugs. The aim is to sharpen the economic intuition on how different anti-drug policies affect the behavior of drug lords who provide drugs and cause much drug related violent crime. Specifically, we model how drug lords respond to two main types of government anti-drug policies: demand and supply oriented. Supply oriented policy is defined as measures increasing the cost of a given quantity of drugs, such as crop eradication, interdiction etcetera. Demand policy concerns prevention and treatment programs, and measures targeting distribution networks, such as, for example, domestic law enforcement, which is novel in the literature.² This policy is modeled within a conflict framework with drug lords over the control of distribution channels for illegal drugs. The model predicts drug use, price and indirectly drug related violent crime. These predictions appear to be consistent with the data.

Let us look at the literature to date on the effect of demand and supply policies on drug use and drug related violent crime.

Skott and Jepsen (2002) model the effects of law enforcement on drug use, focusing on three features of the drug market: addiction, imperfect competition and the presence of switching costs and consumer loyalty. They find that the net effect of this government policy on drug use is ambiguous and a tough stance may in some circumstances be counterproductive. Law

¹Office of National Drug Control Policy 2002.

²It is commonplace in the literature to consider domestic law enforcement as a supply policy. However, we argue that domestic law enforcement can have effects on demand through the disruption of distribution networks.

enforcement is assumed to affect cost parameters and is implicitly modeled. In our model, however, law enforcement is explicitly modeled as a demand oriented policy within the framework of a contest success function yielding different results.

Chiu, Mansley and Morgan (1998) study the trade-off between investing in domestic law enforcement and interdiction of drug supplies at their source. They find the location of enforcement to be irrelevant for the problem and conclude that the choice between domestic or international drug enforcement to only be of secondary importance in choosing effective anti-drug policies. Our results cast doubt on the relevance of their irrelevance result. In our model, domestic (demand policies) and international law enforcement (supply policies) have different effects on drug use, price and associated violent crime.

Burrus (1999) analyzes a model of illegal drug dealers as territorial monopolists who wage turf wars against each other. He considers a two-stage game where the drug dealers first fight each other to gain a turf where, in period two, they will exercise drug monopolies. As in Skott and Jepsen (2002), government law enforcement is modeled as an exogenous (linear) cost parameter. Larger expenditures on law enforcement are associated with lower profit levels for the domestic monopolies and hence, lower sales of drugs.

Due to the nature of the war on drugs, it appears natural to model demand policies within the framework of a contest with drug lords, as opposed to simply a cost parameter. Thus, we obtain qualitatively different results. We take the outcome of the domestic turf wars between drug lords as exogenous (drug turfs tend to be stable over time)³ and focus on the fight between drug lords and the government. As our aim is to analyze the effects of an exogenous government anti-drug law enforcement policy, we do not model the government as an active player.

As the use of drugs and the associated trade breed crime, the US authorities have often taken a "kill two birds with one stone" approach and have given high priority to law enforcement fighting the drugs trade.

The literature on the connection between drugs and violent crime can, according to Paul Goldstein's (1985) conceptual framework, be classified into three main categories:

- Psychopharmacological: Violence due to the direct effect of the drug on the user.
- Economic-compulsive: Violence committed to generate money to purchase expensive drugs.

³Levitt & Venkatesh (1998).

- Systemic: Violence associated with the illegality of the drugs market.

The first two categories are directly tied to the use of drugs, and the third is related to the fact that due to their prohibition, illegal drugs are bought and sold in "black" markets. Assuming that drug use induces more crime and that law enforcement reduces drug use, then law enforcement should also reduce violent crime. The third category has law enforcement affecting violent crime, not through the use of drugs but through the structure of the drugs market.

We focus on the third category, since the literature suggests that the largest percentage of drug related violence is caused by systemic factors.⁴ This category can be divided into two main approaches: The first approach dates back to Gary Becker's seminal 1968 article "Crime and punishment" where crime reduction can occur by reducing the benefits of crime or raising the probability of being caught or the severity of punishment. Hence, more police resources would tend to decrease crime.

The second approach suggests that law enforcement can actually increase violence caused by systemic factors.⁵ Miron (2001) finds empirical evidence that drug enforcement in the US has been associated with increases in the homicide rate. The mechanisms involved are varied. For example, law enforcement may lead to new turf violence or a decreased risk of arrest when committing other types of crimes, as police resources are scarce (and more concentrated on drug related crimes).

Our paper does not explicitly model drug related violent crime. However, we model the amount that drug lords spend on distribution networks, which we link to violent crime.

The paper is structured as follows: We start by presenting some stylized facts on the US market for illegal drugs. Then, we proceed to set up our base line model and present the key results. Section 4 introduces increasing marginal production costs into the base line model. The final section contains a discussion of the results and suggestions for future research.

⁴See, for example, Resignato (2000) for a discussion.

⁵Benson and Rasmussen (1991), Benson, Kim, Rasmussen and Zuehlke (1992), and Resignato (2000).

2 Some stylized facts on the US market for illegal drugs

2.1 US drug policy

The US government considers the drugs trade as a(n) (illegal) market phenomenon. Consumers and producers are assumed to be sensitive to the usual market parameters such as production and distribution costs and prices. The drug policy is therefore geared towards making production and distribution difficult, and expensive so as to drive up consumer prices, thereby reducing use. The two main instruments in fighting the drugs market are demand policies (prevention, education, treatment, domestic law enforcement), and supply policies (international drug law enforcement and interdiction programs). Figure 1 shows the time trends for these two policies:

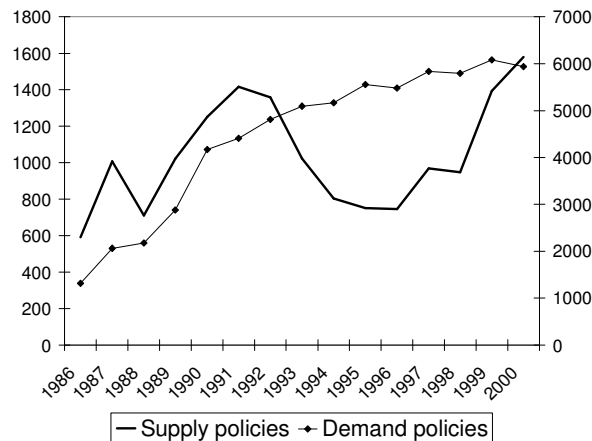


Figure 1. US per capita expenditure on demand and supply policies (USD 1979)

The initiation of the "War on drugs" in the mid-1980s sparked a sharp increase in both demand and supply policies. A large increase in domestic law enforcement boosted the general level of demand policy expenditure well above supply policies.

2.2 Drug use, related violent crime and price

Let us take a closer look at the three main variables in which we are interested. As shown in figure 2, illegal drug prevalence in the US during the last two decades peaked at the beginning of the 80's, then decreased to its minimum level in 1991 and since then, has shown a small tendency to increase. However, as seen over twenty years, the trend is clearly negative.

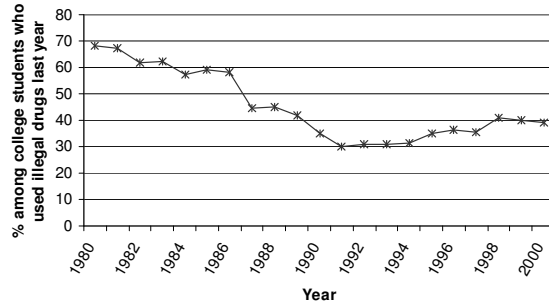


Figure 2. US illegal drug prevalence. Percentage of college students who used illegal drugs last year, time trend.

Figure 3 scatter plots real (1979) USD demand policy expenditure (domestic law enforcement policy plus demand reduction policies) and illegal drug prevalence (we have inserted a second-order polynomial trend line). As can be seen, drug use has indeed declined as expenditure on demand policies has increased, with a small tendency to increase at high levels per capita .

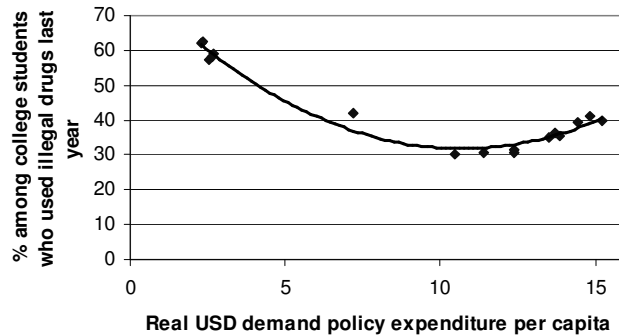


Figure 3. Scatter plot of expenditure per capita (1979 USD) on demand policy and illegal drug prevalence.

Drug related violent crime, in this case represented by drug related homicides, presents a puzzling relationship with demand policies. Figure 4 (with an inserted second-order polynomial trend line) scatter plots the annual total number of drug related homicides and demand policy expenditure in the US for the period 1983 - 2001.

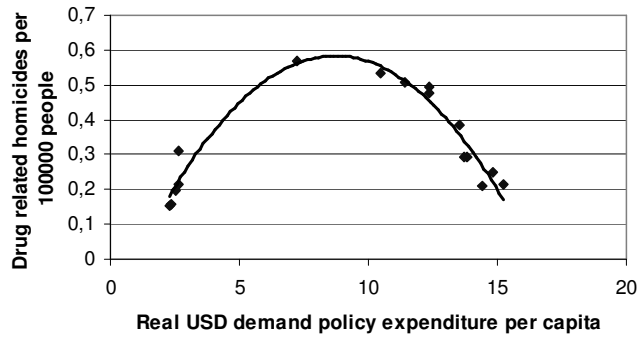


Figure 4. Scatter plot of drug related homicides per 100000 people and demand policy expenditure per capita (real 1979 USD)

This hump-shaped relationship is not well explained by the previous literature, which assigns either a positive or a negative effect of demand policies on drug related violent crime.

Figures 5 and 6 show the retail price trend for cocaine, heroin and marijuana in the US during the last two decades. They show two different trends. Cocaine and heroin prices have been decreasing throughout the two decades, while the retail price of marijuana first increased until 1991 and then decreased.

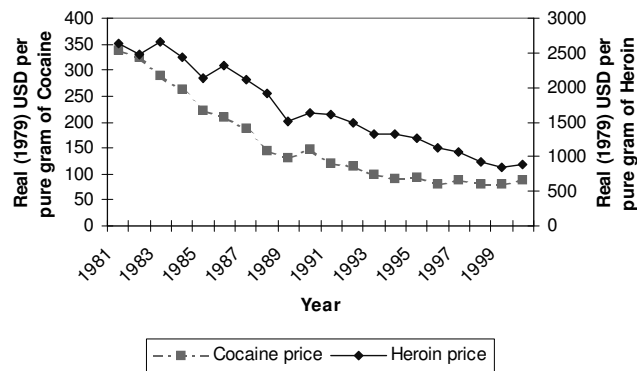


Figure 5. Cocaine and heroin retail price time trends.

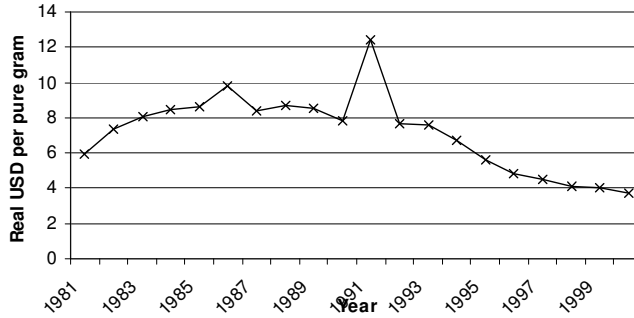


Figure 6. Marijuana retail price time trend.

What is somehow striking is the fact that given the large and increasing amounts spent on demand and supply policies with the aim of increasing the retail price, the trend for cocaine and heroin is largely negative (!).

With these puzzling data in mind, we turn to our model.

3 The model

Assume that there are $m > 0$ identical drug lords attempting to sell illegal drugs in a Cournot setting. Each drug lord i does this by spending resources, $x_i \geq 0$, on maintaining a distribution network. The resources could, for example, be spent on guns, paying individual drug dealers, etcetera. Following Burrus (1999), for example, we define a linear aggregate demand function for illegal drugs, $a - bp$, where $a \geq 0$, $b \geq 0$, and the price of drugs $p > 0$. The government spends resources on demand policies, d , with the aim of reducing the share of total demand drug lords can access. Hence, this makes it more difficult for consumers to find drug dealers. We define the share of demand drug lords can reach by $z \in [0, 1]$. The expected aggregate demand function then becomes $q^d = z(a - bp)$, or expressed in terms of inverse demand:

$$p = \frac{a}{b} - \frac{q^d}{bz}. \quad (1)$$

Let z be a function of how much drug lords and the government spend. Specifically, let the share of aggregate demand available to drug lords, z , be the ratio of total resources spent by all drug lords to the sum of drug lords and demand policy spending:⁶

⁶For mathematical convenience, we assume x and d to be infinitely divisible.

$$z \left(\sum_{j=1}^m x_j, d \right) = \frac{\sum_{j=1}^m x_j}{\sum_{j=1}^m x_j + d}. \quad (2)$$

This is a simple version of a ratio contest success function commonly used in the conflict literature.⁷ This specification has the property that expenditure by an individual drug lord increases the share of aggregate demand available to all drug lords. We believe this to be a reasonable property, since any increase in drug lord expenditure stretches government resources. Thus, the "thin red line" of demand policies becomes even thinner.

Apart from paying for distribution networks, drug lords buy drugs from abroad at the constant per unit wholesale price of γ . Although the assumption of constant marginal cost is commonplace in agricultural production functions⁸ we will investigate the effect of increasing marginal cost in section four. γ is assumed to increase if the government increases its spending on supply policies, such as international crop eradication and interdiction.⁹ The price decreases if, for example, more land is available for growing drugs, which might be a consequence of government anti-drug policies in the producing country.

Having defined revenue and cost functions, the expected profits of drug lord i are then:

$$\pi_i = p q_i^s - \gamma q_i^s - x_i. \quad (3)$$

Drug lord i is thus faced with a profit maximization problem where he/she must choose the optimal amount to spend on distribution networks and the quantity of drugs to sell, q_i^s , given the expectations of government drug policies and other drug lords. Using equations 1 and 2, and the assumption of market clearing, that is, $q^d = \sum_{j=1}^m q_j^s$, the problem can be stated as:

$$\max_{x_i, q_i^s} \pi_i = \left(\frac{a}{b} - \frac{\sum_{j=1}^m q_j^s}{b} \frac{\sum_{j=1}^m x_j + d}{\sum_{j=1}^m x_j} - \gamma \right) q_i^s - x_i. \quad (4)$$

⁷Tullock (1980); see also Hirshleifer (1991) and Skaperdas (1996) for a discussion on contest success functions. Siven and Persson (2001) also discuss a model where the ratio between police officers to criminals increases the probability of arrest.

⁸See the economic geography literature, for example, Krugman (1991).

⁹It is reasonable to assume that the drug producers could respond to government anti-drug law enforcement in the same way as the drug lords in the US by changing the size of their organization. However, the cost of producing a given quantity of drugs would very likely monotonically increase due to any increase in international anti drug law enforcement.

The first order condition with respect to q_i^s is:

$$\frac{\partial \pi_i}{\partial q_i^s} = \frac{a}{b} - \frac{2q_i^s + \sum_{j \neq i}^m q_j^s}{bz \left(\sum_{j=1}^m x_j, d \right)} - \gamma = 0.$$

Assuming symmetry, $q_i^s = q_j^s = q$, $\forall j$, and then solving for q yields:

$$q = \frac{bz \left(\sum_{j=1}^m x_j, d \right)}{(m+1)} \left(\frac{a}{b} - \gamma \right). \quad (5)$$

We assume that $q > 0$, that is, as we do observe a market for drugs, we are only interested in positive values of q . This implies that $\frac{a}{b} - \gamma > 0$. The first-order condition with respect to x_i is:

$$\frac{\partial \pi_i}{\partial x_i} = \frac{\sum_{j=1}^m q_j^s}{b} q_i^s \left[\frac{d}{\left(\sum_{j=1}^m x_j \right)^2} \right] - 1 = 0. \quad (6)$$

Assuming symmetry ($x_i = x_j = x$, $q_i^s = q_j^s = q$, $\forall j$) and solving for x :

$$x = q \sqrt{\frac{d}{bm}}. \quad (7)$$

Using equation 5 and that symmetry implies $z^* = \frac{mx^*}{mx^* + d}$, simplifying and multiplying by m yields:

$$mx^* = -d + \frac{\sqrt{m}}{(m+1)} \left(\frac{a}{b} - \gamma \right) \sqrt{bd}. \quad (8)$$

Hence, in equilibrium, aggregate drug lord expenditure on distribution networks increases in the intercept of the demand curve, a , decreases in the number of drug lords, m , wholesale price, γ , and price sensitivity, b . What is interesting to note is that mx^* has a non-monotonic relationship with government demand policies, d . At low levels of demand policy spending, the relationship is positive while turning negative at high such levels. Intuitively, at low levels of spending, it pays to fight back if more resources are spent on demand policies. However, at higher levels, it is better to respond by cutting back, due to the decreasing marginal returns.

It may be somewhat surprising that the amount spent on distribution networks is negatively related to the total number of drug lords, m . The opposite relationship might be expected as the total amount of resources

spent (in this case on distribution networks) in a typical rent seeking contest is positively related to the degree of competition¹⁰. However, in this model, the contest involving drug dealers is between the government and the drug lords. The effect of incremental spending is such that it increases the share of demand available to all drug lords, while only drawing resources from the spending drug lord. Hence, the other drug lords free ride. Thus, ceteris paribus, if competition in the drugs market increases, the equilibrium expenditure on distribution networks decreases.¹¹

We summarize the comparative statics of equation 8 in proposition 1.

Proposition 1 *The total amount spent on distribution networks, mx^* : (i) Increases monotonically in the intercept of the demand curve, a . (ii) Decreases monotonically in the number of drug lords, m , wholesale price, γ , and price sensitivity, b . (iii) Has a non monotonic relationship with government demand policies, d . At low levels of demand policy spending, the relationship is positive while turning negative at high levels.*

Proof. Immediate with respect to a , b and γ . See the Appendix for variables m and d .

Let us proceed to examine equilibrium drug use in the economy. First, we find the equilibrium share of available demand, $z^*(mx^*, d)$, by using equation 8 in equation 2:

$$z^*(mx^*, d) = 1 - \frac{(m+1)}{\sqrt{m}} \frac{1}{\left(\frac{a}{b} - \gamma\right) \sqrt{\frac{b}{d}}}. \quad (9)$$

Second, to find the aggregate amount of sold drugs, mq^* , we insert equation 9 into equation 5 and multiply by m :

$$mq^* = \frac{m}{(m+1)} b \left(\frac{a}{b} - \gamma \right) - \sqrt{b d m}. \quad (10)$$

We see that mq^* decreases, as expected, with price sensitivity, b , wholesale price, γ , and demand policy spending, d and increases in the intercept of the demand curve, a . Moreover, mq^* has a non-monotonic relationship

¹⁰See, for example, Tullock (1980).

¹¹A key assumption for this result to hold is that expenditure on distribution is not used for fighting turf wars with other drug lords. A more comprehensive (and much more complex) model could allow for a dual use of expenditure (both fighting the police and other drug lords). The net effect of a lower market concentration on the total amount of drug lords would then probably be ambiguous as the effects of free riding and intensified turf competition work in opposite directions.

with respect to the number of competing drug lords, m .¹² At low levels of m , the relationship is positive while turning negative at high levels. There are two main effects at play here: First, a higher m decreases aggregate spending on distribution networks, that is, the free rider effect, which reduces available demand and thereby limits the amount sold. Second, the increase in (Cournot) market competition decreases the price, which increases demand. So, at low levels of competition, an additional drug lord means that more drugs will be sold as the competition effect dominates the free rider effect.¹³ The comparative statics for the aggregate amount of drugs sold is summed up in proposition 2:

Proposition 2 *The quantity of sold drugs, mq^* : (i) Decreases monotonically with price sensitivity, b , wholesale price, γ , and government demand policy spending, d . (ii) increases monotonically in the intercept of the demand curve, a . (iii) Has a non monotonic relationship with respect to the number of competing drug lords, m . At low levels of m , the relationship is positive while turning negative at high levels.*

Proof. Immediate with respect to a , b , d and γ . See the Appendix for m .

The equilibrium price in the symmetric case is derived from equation 1, noting that $q^d = mq$, where q is given by equation 5:

$$p^* = \frac{a}{b} - \frac{m}{(m+1)} \left(\frac{a}{b} - \gamma \right). \quad (11)$$

Note that equilibrium price is not a function of government demand policy spending, d . Why? Government demand policies affect both the demand and the supply of drugs through z . For example, more domestic law enforcement shrinks demand as it reduces the share of total available demand, which tends to decrease the price. Drug lords then respond by reducing sales, which tends to increase the price. In our model, these two effects cancel out exactly (due to constant average and marginal production costs). The following proposition summarizes the comparative statics of equilibrium price, equation 11:

Proposition 3 *Equilibrium price, p^* , (i) decreases monotonically in price sensitivity, b , and the number of drug lords, m , and (ii) increases monotonically in the intercept of the demand curve, a , and wholesale price, γ . (iii) p^* is not affected by z .*

¹²The relationship is non-monotonic providing that the market is sufficiently profitable. See the Appendix, proof of proposition 2 for a formal treatment.

¹³Once more, if we allow for a model with turf wars, the free rider effect might disappear.

Proof. *Immediate.*

Section 4 investigates the effect of introducing increasing marginal production costs.

4 Increasing marginal production costs

As is clear from proposition 3, price is, somehow surprisingly, not affected by demand policies in the base line model. This result comes from two things: (i) the assumption of constant marginal cost and (ii) the market scaling effect of demand policies. In this section we introduce the assumption of increasing marginal cost to check the robustness of the predictions from the base line model. For analytical convenience we specify per unit wholesale price by the simplest possible functional form: $\gamma (q_i^s)^2$. Hence, the profit function is now defined as:

$$\pi_i = pq_i^s - \gamma (q_i^s)^2 - x_i. \quad (12)$$

Using equations 1 and 2, and the assumption of market clearing, that is, $q^d = \sum_{j=1}^m q_j^s$, the problem can be stated as:

$$\max_{x_i, q_i^s} \pi_i = \left(\frac{a}{b} - \frac{\sum_{j=1}^m q_j^s}{b} \frac{\sum_{j=1}^m x_j + d}{\sum_{j=1}^m x_j} \right) q_i^s - \gamma (q_i^s)^2 - x_i. \quad (13)$$

The first order condition with respect to q_i^s is:

$$\frac{\partial \pi_i}{\partial q_i^s} = \frac{a}{b} - \frac{2q_i^s + \sum_{j \neq i}^m q_j^s}{bz \left(\sum_{j=1}^m x_j, d \right)} - 2\gamma q_i^s = 0.$$

Assuming symmetry, $q_i^s = q_j^s = q$, $x_i = x_j = x$, $\forall j \neq i$, and then solving for q yields:

$$q = \frac{a}{(m+1) \frac{mx+d}{mx} + 2b\gamma}. \quad (14)$$

We assume that $q > 0$, that is, as we do observe a market for drugs, we are only interested in positive values of q . The first order condition with respect to x_i is:

$$\frac{\partial \pi_i}{\partial x_i} = \frac{\sum_{j=1}^m q_j^s}{b} q_i^s \left[\frac{d}{\left(\sum_{j=1}^m x_j \right)^2} \right] - 1 = 0. \quad (15)$$

Assuming symmetry ($x_i = x_j = x$, $q_i^s = q_j^s = q$, $\forall i \neq j$) and solving for x :

$$x = q\sqrt{\frac{d}{bm}}. \quad (16)$$

Combining equations 14 and 16 and multiplying by m we find the equilibrium aggregate values:

$$mq^* = \frac{ma - (m+1)\sqrt{b dm}}{(m+1) + 2b\gamma} \quad (17)$$

$$mx^* = \frac{a\sqrt{\frac{dm}{b}} - d(m+1)}{(m+1) + 2b\gamma}. \quad (18)$$

Solving for equilibrium price:

$$p^* = \frac{\frac{a}{b}(1 + 2b\gamma) - 2\gamma\sqrt{dbm}}{m+1 + 2b\gamma}. \quad (19)$$

We summarize the comparative statics of equations 17, 18, and 19 with respect to the policy variables d and γ in proposition 4.

Proposition 4 *mq^* decreases in both d and γ . mx^* has a concave non-monotonic relationship with respect to d . At low levels of d , the relationship is positive while turning negative at high levels. mx^* decreases with γ . p^* decreases in d and increases in γ .*

Proof. Immediate with respect to $\frac{\partial mq^*}{\partial d}$, $\frac{\partial mq^*}{\partial \gamma}$, $\frac{\partial mx^*}{\partial \gamma}$, $\frac{\partial p^*}{\partial d}$, and $\frac{\partial p^*}{\partial \gamma}$. See the Appendix for $\frac{\partial mx^*}{\partial d}$.

We note that the only qualitative difference from the baseline model is that price now decreases with demand policies. The intuition behind the result is that as demand policies scale down market size ($\frac{\partial mq^*}{\partial d} < 0$) production costs no longer fall proportionately. A lower volume implies lower marginal costs and lower price, which appears to be consistent with data.

5 Discussion

Our model predicts that, ceteris paribus, drug use will decline with higher expenditures on any drug policy and increase with the number of drug lords in the retail market. Given the positive trends in anti-drug policy spending

and the long-run decline in drug use over the last twenty years, the prediction seems reasonable.

According to our model, the small tendency of increasing drug use in the last ten years must be explained by a factor other than any of the two drug policies. One possible explanation could be that the wholesale price has decreased and/or the drugs market has been affected by an increase in the number of drug lords. In spite of high amounts of resources invested in international and interdiction programmes that may have increased the wholesale price through increased production and transportation costs, these costs may have decreased due to the use of better production and transportation technologies. It is difficult to determine whether this is the case. However, our model predicts that if the number of drug lords increases from a low level, the amount of drugs sold increases. This is well supported by empirical evidence that shows how the structure of the market for illegal drugs in the US (and the source countries) has changed from being concentrated to being more competitive, culminating in the capture of the main drug lords (the Cali and Medellin cartels) in the early 1990's¹⁴. Yet another explanation could be a change in consumer preferences, but at present, we have no data for investigating this.

Our analysis predicts that demand policies produce a non-monotonic response with respect to the amount spent on distribution networks. An important share of this spending is very likely to be used for paying drug dealers and purchasing weapons. There is strong theoretical and empirical evidence linking the number of drug dealers to drug related homicides. Drug dealers engage in violence for many reasons. The common denominator is the fact that disputes within the black market for drugs cannot be solved peacefully within the legal system.¹⁵ Instead, dealers use violence to scare off potential entrants in the drug trade, fight for turf with other drug dealers, pose credible warnings to users late in paying drug debts etcetera. Further, as drug dealers frequently carry large sums of money and valuable drugs, they become "fat targets" for robbery.¹⁶ As drug dealers are, on average, thus prone to violence, more drug dealers implies more violence. However, the negative effects of more drug dealers are not constrained to the illegal drugs market. Most of the drug dealers are poor juveniles in inner cities closely integrated with other youths in their neighborhood. As the drug dealers arm themselves with fire arms, some of these weapons also "diffuse" to other youths. As guns become more common, non drug dealing youths may get guns for

¹⁴See, for example, United States General Accounting Office, 2002.

¹⁵Miron (2001b).

¹⁶Blumstein, Rivara and Rosenfeld (2000).

self protection or even for achieving social status.¹⁷ As a result, fights that would otherwise have been resolved with fists or other less lethal weapons are increasingly resulting in deadly shootings. Hence, the amount spent on distribution networks is likely to be connected to drug related homicides. Remark 1 summarizes our discussion on this link.

Remark 1. *As our model predicts the amount spent on distribution networks (proposition 2), it can also help explain the drug related homicide rate.*

Proposition 2 and remark 1 suggest the relationship between demand policy expenditure and drug related violent crime to be non monotonic (hump shaped). Thus, we can provide one possible theoretical explanation for the puzzling empirical relationship between the two above variables.

As for the cocaine and heroin retail price, proposition 4 predicts that demand policy expenditure decreases price through the reduction in market size and the associated decreased marginal production cost while supply policies tend to increase the retail price. Figure 1 shows that demand policy expenditure has outweighed supply policy expenditure. Hence, our model provides a possible theoretical explanation for the decreasing retail price trend.

Explaining the marijuana retail price trend is more difficult. First, the main difference, apart from potency and prevalence, between the two types of drugs is that heroin and cocaine are largely manufactured abroad while an important share of US consumed marijuana is domestically produced. It is then likely that demand policies, for example domestic law enforcement, would affect marginal production costs for marijuana directly and not only through the reduction in market size. More domestic law enforcement would tend to make it more risky and expensive to grow any amount of marijuana.

Summing up, our model provides a possible theoretical explanation of the trends in drug use, price and drug related violent crime in the US since the beginning of the eighties. It is based on the assumption that drug lords can, to some extent, counteract demand policies by varying the amount spent on distribution networks. The key element of the model is that the fight is between the government and the drug lord over distribution channels, by means of a contest success function. Previous literature has, to a large extent, treated government anti-drug policies as a linear cost parameter in the drug lord's profit function. This produces a monotonic and negative relationship between demand and supply policies and drug use and drug related crime. As is seen in the data, the relationship between demand policy expenditure and drug related violence appears to be non-monotonic as would be predicted by our model. The goal of US policy has been to reduce both drug use and

¹⁷Blumstein, Rivara and Rosenfeld (2000), Blumstein and Rosenfeld (1998).

drug related crime by increasing the price of drugs, thereby reducing the profitability from the illegal drugs trade. Our model suggests price to be a poor measure of the success of this policy.

During the mid-eighties, demand policy expenditure was increasing from a low level and, according to our model, managed to decrease drug use, while actually driving the increase in drug related crime. At that time, US anti-drug-policy did not "kill two birds with one stone", but rather killed one and fed the other. However, as demand policy expenditure has been boosted to a level where drug lords find it optimal to downsize their organizations, drug use and associated violent crime are dropping simultaneously. Hence, at these high levels of demand policy expenditure, two birds are indeed being killed with one stone.

To explain US government behavior, we would need to model the government as an active player. The aim of this paper has merely been to derive a best response to government drug policies. We do believe, however, that endogenizing government policy would be a fruitful line of future research. Although it looks at first sight interesting to endogenize the number of drug lords, this has to be treated with some caution. In the real world, drug lords form cartels with different sizes. As anti-drug policies can be aimed to break up some of the bigger cartels, this can actually lead to an increase in the number of drug lords. Therefore, if we want to understand the effect of endogenizing the number of drug lords we should take into account this asymmetry. We do believe that by keeping the number of drug lords exogenous is possible to have a better understanding of the effects that demand and supply anti-drug policies have on the illicit drug industry in final destination countries.

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6 Appendix

6.1 Proofs

Proof of proposition 1

First, we need to show that $\frac{\partial mx^*}{\partial m} < 0$ where $mx^* = -d + \frac{\sqrt{m}}{(m+1)} \left(\frac{a}{b} - \gamma \right) \sqrt{bd}$. Remember that we have assumed $\frac{a}{b} - \gamma > 0$. Then, it is sufficient to show that $\frac{\partial \frac{\sqrt{m}}{(m+1)}}{\partial m} < 0$.

Taking the derivative: $\frac{\partial \frac{\sqrt{m}}{(m+1)}}{\partial m} = \frac{1}{2\sqrt{m}(m+1)} - \frac{\sqrt{m}}{(m+1)^2} < 0$.

Rearranging yields: $m < 2m - 1$, which is true for $m > 1$.

Second, we want to prove that mx^* has a hump-shaped relationship to d for positive values of mx^* and d . It is sufficient to show that equation 8 is strictly concave and achieves a maximum for $d > 0$.

First, let us examine the concavity:

$$\frac{\partial^2 mx^*}{\partial d^2} = -\frac{\sqrt{m}}{4(m+1)} \left(\frac{a}{b} - \gamma \right) \sqrt{b} d^{-\frac{3}{2}} < 0.$$

Hence, we have strict concavity.

Further, at what value of d does equation 8 have its peak value?

Setting the first derivative of equation 8 with respect to d to zero and solving for d yields:

$d^{\max} = \left(\frac{\sqrt{m}}{2(m+1)} \left(\frac{a}{b} - \gamma \right) \sqrt{b} \right)^2 > 0$. Hence, equation 8 peaks for a positive value of d .

Q.E.D.

Proof of proposition 2

We need to show that $mq^* = \frac{m}{(m+1)}b(\frac{a}{b} - \gamma) - \sqrt{b d m}$ has a hump-shaped relationship to m for positive values of mq^* . For notational convenience, we rewrite

$$mq^* = \frac{m}{(m+1)}\alpha - \beta\sqrt{m}, \quad (20)$$

where $\alpha = b(\frac{a}{b} - \gamma)$ and $\beta = \sqrt{bd}$.

Let us examine how mq^* depends on m :

$$\frac{\partial mq^*}{\partial m} = \frac{\alpha}{(m+1)^2} - \frac{\beta}{2\sqrt{m}} \quad (21)$$

This will be positive if

$$\frac{2\alpha}{\beta}\sqrt{m} > (m+1)^2 \quad (22)$$

We note that the left hand side is strictly concave while the right hand side is strictly convex in m . For the smallest possible number of drug lords, $m = 1$, the right hand side equals 4. For equation 21 to be strictly positive, $\frac{2\alpha}{\beta}$ must be greater than 4. Due to the concavity of the left hand side and the convexity of the right hand side of equation 22, increasing m will eventually make equation 21 negative. $\frac{2\alpha}{\beta} > 4$ implies that $\alpha > 2\beta$. Plugging in $\alpha = 2\beta$ in equation 20 yields $mq^* = 0$ for $m = 1$. For any value of $\alpha > 2\beta$, $mq^* > 0$ for $m = 1$. As $\frac{\partial mq^*}{\partial m} > 0$ for $\alpha > 2\beta$ and $m = 1$, we know we are in the positive quadrant.

Q.E.D.

Proof of proposition 4

From equation 18 we know that if $m^*x^* > 0$ then $d < \frac{a^2m}{(m+1)^2b}$ has to hold.

Then $\frac{\partial m^*x^*}{\partial d} = \frac{1}{(\frac{m+1}{b})+2\gamma} (\frac{a}{b}\frac{1}{2}\sqrt{\frac{m}{bd}} - \frac{1}{b}(m+1)) \geq 0$ and simplifying we get: $\frac{a^2}{4(m+1)^2}\frac{m}{b} \geq d$. Because $\frac{\partial^2 m^*x^*}{\partial^2 d} = \left(\frac{1}{(\frac{m+1}{b})+2\gamma} \right) \left(-\frac{a}{b}\frac{1}{4d}\sqrt{\frac{m}{bd}} \right) < 0$, m^*x^* is concave with respect to d , with $d = \frac{1}{4} \left(\frac{a^2m}{(m+1)^2b} \right) > 0$ as the critical point.

Q.E.D.